

**DEWEY ON THE REFLEX ARC  
AND THE DAWN OF THE DYNAMICAL APPROACH  
TO THE STUDY OF COGNITION**

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**1. Introduction**

In this article I assess the relevance that the pragmatist philosopher John Dewey, and particularly his famous 1896 article “The reflex arc concept in psychology”, assume for a historical revision of the group of research programs that here I will conveniently call ‘embodied cognitive science’, with a focus on the related dynamical approach. The specific contribution of my work focus on the shift from Dewey’s conceptual analysis in his article to the way in which during the last years those research programs have developed their methodological profile and put it down to work in the experimental and modeling practices. The hypothesis that I here defend is that, under a certain interpretation, Dewey’s article plays the role of the main intellectual precursor in the development of embodied cognitive science in its particular dynamicist strand.

My contribution builds on the following steps. After a brief introduction to the embodiment movement in the cognitive sciences, I give reasons to justify a degree of continuity between these recent developments and Dewey’s pragmatist philosophy, taken as a whole. I then turn to a thorough analysis of the central ideas in Dewey’s article, following certain precisions regarding its interpretation: I divide my considerations between the critical and positive contributions which can be extracted from the article and which can justifiably be redirected to the lines of work within the dynamical approach in the cognitive sciences. In this way, I specify in what sense Dewey’s contributions establish certain decisive conceptual bases underlying those lines of research.

Finally, it is appropriate to mention some of the existing publications driven by motivations similar to mine here. Firstly, Bredo (1994) draws a connection – although not on the methodological level that interests me here – between Dewey’s proposal and the situated cognition movement of the late 80s, with a special interest in the educational aspect of the problem. Another precedent is Gallagher (2009), who specifically shows the continuity existing between Deweyan philosophy of mind and the so called enactive view, in the particular version developed by philosopher Alva Noë (2004, O’Regan & Noë 2001). The main difference between my approach and that of these authors is that I am interested in the philosopher’s contributions as fully immersed in the philosophy of the special sciences, and accordingly as solutions to problems concerning the establishment and conduction of scientific research.

**2. A quick glance at embodied cognitive science and the dynamical approach**

Embodied cognitive science (Clark 1999) can be briefly defined as a vast group of research programs from different areas of the cognitive sciences, comprising research based on the idea that cognitive abilities necessarily integrate the complex interplay between the agent’s brain and body as well as relevant features of the proximate environment. Many of these research programs promote an enrichment of abstract models which make possible to approach the abovementioned complex interplay of simple mechanisms encompassing bodily and environmental factors for the emergence of intelligent behavior.

Among the conglomerate of programs that can be included within the general denomination of embodied cognitive science and that in addition resulted in experimental and modeling approximations, the dynamical approach (Beer 2000, Port & van Gelder 1995) has had, probably more than any other, a strong impact on the field. The dynamical approach stands out, on the one hand, for its innovative and radical character vis-à-

vis classical approaches such as the information processing paradigm (for example, Palmer & Kimchi 1986 and Simon 1979) or, more generally, cognitivism (for example, Haugeland 1975) and, on the other hand, for its characteristic brand of cognitive-scientific approach. This last point rests mainly on the application of the mathematical theory of dynamical systems (Strogatz 1994) to the study of cognitive processes. This theory provides a rich mathematical language as well as modeling and graphical tools for the precise description of the behavior of complex systems in their temporal evolution.

A dynamical model consists in a state space defined in terms of dynamic variables that represent the relevant properties of the system and a set of non-linear equations which describe how the state of the system varies in time. The behavior of the system is then generally compared with experimental data about the cognitive performance of real agents. The explanatory focus is set on the structure of the space of the system's possible trajectories (behaviors) and the internal and external forces which shape them; the inputs are thus construed not as specifying an internal state which somehow describes an external state of things but as a source of perturbations in the system's internal dynamics.

Along these lines, the dynamical approach mainly entails understanding an organism's behavior as an exclusive property of the coupled system organism-environment, not ascribable individually to any of its parts. In turn, the relations between the nervous system and the body of the organism constitute in the same way a coupled system (cfr., Beer 2000: 97). Two systems are said to be coupled when the parts that comprise each of them engage in dense interactions of mutual influence, on account of which the alteration of one component by the action of another in turn will affect it and so on. I end here this very brief presentation of embodied cognitive science and its dynamicist strand.

### **3. Common threads in general epistemology**

Before turning to my analysis of the 1896 article and its connection to the dynamical approach, it is important to highlight the general epistemological position defended by Dewey – his stand in Experience and Nature being especially relevant – to the extent that it shows some common threads with embodied cognitive science, conceived as a group of related approaches in the cognitive sciences. At first sight, this affinity is straightforward. One ought to firstly point out that, as a pragmatist philosopher (and as his distinguished predecessors, Charles Peirce and William James), Dewey defends a view of beliefs as tools or guides for action. For example, following Godfrey-Smith (1996a), the question of knowledge according to Dewey is that of explaining how structures and patterns of agent-environment interactions can adapt and evolve to help dealing constructively to changing circumstances that pose new problems, challenges and opportunities to the organism.

However, as Godfrey-Smith (cfr. 1996a: 6) points out, Dewey departs from the preceding pragmatist tradition inasmuch as he explicitly describes intelligent action as a response to problematic situations of the environment where it develops. In particular, he stressed the relevance to psychological research of taking into account the structure of the environment in which cognitive agents operate: along these lines, it can be argued that Dewey defended a strongly interactionist view of cognition and the agent-environment relationship (I will return to this point later on). This places him in the vicinity of the sort of worries that drive embodied cognitive science: a focus on lower level cognitive skills and the structure of an organism's environment.

From the standpoint of contemporary philosophy of cognitive science, this last point is not at all trivial, attending specifically to the methodological solipsism

(Fodor 1980) characteristic of the chomskian tradition, which directed cognitive-scientific inquiry to an internal center of operations responsible for intelligent behavior. A closely associated idea is a particular view of perception understood as the input to those internal structures and a corresponding view of action understood as its output: an idea that is the core target of the critique and the proposal that, as we will see, are put forward in Dewey's article.

The work of Johnson and Rohrer (cfr., 2006: 19) is, as far as I know, the first philosophical attempt to explicitly portray Dewey and, in general, the pragmatist tradition as a predecessor of the recent embodiment movement. It is useful to attend to their reconstruction of five general tenets in the pragmatist view of cognition that have been somehow inherited by embodied cognitive science:

1. Cognition is the result of evolutionary processes.
2. Cognition is situated within a dynamic ongoing organism-environment relationship.
3. Cognition operates relative to the needs, interests, and values of organisms (that is, it is problem-centered).
4. Cognition is concerned with solutions that work well enough relative to the current situation (that is, it is not directed towards perfect solutions).
5. Cognition is often social and carried out cooperatively.

These five tenets offer a global idea of the general notion of cognition shared by the pragmatist tradition and the embodiment movement.

To finalize these considerations regarding the epistemological position of Dewey qua exponent of American pragmatism, I'd like to transcribe some quotations that I find very eloquent in regards to its strong connection with embodied cognitive science as I have depicted it. Consider for example the following

extract from the introduction to *Essays in Experimental Logic*:

Hands and feet, apparatus and appliances of all kinds are as much a part of [thinking] as changes in the brain. Since these physical operations (including the cerebral events) and equipments are a part of thinking, thinking is mental [...] because of what physical acts and appliances do. (Dewey 1916: 14)

This quotation not only manifests roundly the relevance of taking into account the body for a study of the brain's operations and, by extension, the cognitive architecture on an agent, but it also points clearly in the direction ("apparatus and appliances") of the movement behind cognitive extension and the extended mind thesis (Clark & Chalmers 1998), closely aligned with embodied cognitive science.

Consider now the following extract from *Experience and Nature*: "To see the organism in nature, the nervous system in the organism, the brain in the nervous system, the cortex in the brain is the answer to the problems which haunt philosophy" (Dewey 1925: 198). It is impressive to see this idea being put back to work today in the embodied cognition literature in cognitive neuroscience, particularly regarding the recent attack on so-called neurocentrism, i.e. the idea that no factor external to the functioning of the brain is relevant to cognitive-neuroscientific research (see, for example, Chiel & Beer 1997, and Thompson & Varela 2001). It's time to finally move on to "The reflex arc concept..." and, specifically, its relation to the dynamical approach in the cognitive sciences.

#### **4. Dewey and the concept of reflex arc in contemporary cognitive science**

##### **4.1. "The reflex arc concept in psychology" and its interpretation**

"The reflex arc concept in psychology" is regarded as one of the most important articles in the history of scientific psychology. As Leahey (1998: 348) points out, in 1943

the article was selected as one of the most relevant pieces of work to ever be published in the *Psychological Review* and it remains as well one of the most cited articles in the journal. Now, leaving aside its well-known role as a foundational contribution to American functional psychology, I intend to show in what follows that the conceptual depth of the article goes well beyond its already acknowledged contribution to the history of psychology: the article's conceptual richness is still very alive today and particularly because, as I will here argue, it resonates strongly with the theoretical and methodological profile of the outlined dynamical approach in the cognitive sciences.

A standard interpretation of the article associates it mainly with a critique to certain assumptions, tied to the concept of 'reflex arc', underlying the pre-behaviorist psychology of the historical period when it was written. Dewey starts identifying in the idea of the reflex arc a certain response, at the moment increasingly endorsed, to the need of a general working hypothesis capable of systematizing vast amounts of experimental data that were being collected. Dewey's main objective is to show that the then novel idea of the reflex arc was still insufficient to displace certain prevailing principles of classification and explanation in the psychology of his time. Towards this end, the author approaches specifically the problem of sorting out the consequences of taking the notions of 'stimulus' and 'response' as independent ones, a maneuver which Dewey himself defines as a sort of persisting dualism:

The older dualism between sensation and idea is repeated in the current dualism of peripheral and central structures and functions; the older dualism of body and soul finds a distinct echo in the current dualism of stimulus and response. Instead of interpreting the character of sensation, idea and action from their place and function in the sensory-motor circuit, we still incline to interpret the latter from our preconceived and preformulated ideas of rigid distinctions between sensations, thoughts and acts. (Dewey 1896: 357-8)

It is worth pointing out that the conceptual contributions Dewey is set to develop by elaborating on this strong statement do not stand apart from the possibility of their concrete application to some line of psychological research. What Dewey does at the outset is highlighting a particular analysis of action, already endorsed by the psychology of his time, under certain descriptive resources ('stimulus' and 'response'), which, in his opinion, constitute conceptual abstractions of a continuous and coordinated sequence of events. Specifically, he is going to argue later on that, if the word 'stimulus' is to be applied to the description of agent-environment coordination it should be used to refer not to environmental events (i.e., external events) but to those aspects of the coordination which specify the state of affairs (the stage of organization) that it is trying to maintain.

In a straightforward way, then, our philosopher intends to restrict the semantic scope of the concepts of stimulus / sensation and response / action within the context of psychological theorization and research setting. Given this, I attempt in what follows to retrieve the "methodological sediments" associated with the outlined conceptual contribution by Dewey, or, in other words, to show in what way specific descriptive resources taken as general assumptions impact on the praxis of psychological research – in consonance with this, it is worth mentioning that Dewey concludes his article stating that "[t]he point of this story is in its application" (Dewey 1896: 370), an elaboration that the author postpones to another (vanished) occasion. It will later become clear how the counterpart of Dewey's critical assault is picked up by the recent dynamical approach.

Before moving on to this, however, it's important to define certain lines of interpretation of an article that in this sense has historically turned out to be troublesome. According to Ballantyne (1996), the article has systematically been misinterpreted and underestimated.

For example, it has been read as a defense of the concept of 'reflex arc' by some proto-behaviorists in the sense that Dewey was trying to apply a physiological concept to psychology. More commonly, it has been interpreted as an original proposal surrounding the idea of a reflex circuit (this is the kind of interpretation of great names of functional psychology, and Dewey's fellow colleagues at the University of Chicago, such as James Angell and Harvey Carr) instead of the already outdated concept of reflex arc.

The first interpretation – reconstructed and criticized by Manicas (2002), and attributed to historians like Ernest Hilgard, who saw Dewey as part of an ongoing process that lead to Watson's behaviorism – is patently wrong as far as the object of Dewey's conceptual analysis is the psychological appropriation (and the associated consequences) of a concept originally product of XIX century physiology: that appropriation and its consequences are exposed in the hands of Dewey to a hard critique in the context of psychological theory.

On the other hand, the second interpretation can be undermined by analyzing the text. A view along these lines is offered by Ballantyne (1996), who criticizes the scheme 'reflex arc versus sensorimotor circuit' and subsequently rejects the idea of the sensorimotor circuit as a position forged and defended by Dewey so as to replace another purportedly inadequate position. I tend to adhere to Ballantyne's reflections, particularly with regards to their implications to the kind of Deweyan philosophical contribution which, as I've already stated, would take him not so much as an epistemologist (in the traditional sense) than as a philosopher of the special sciences, in this case, a philosopher of psychology. However, I recognize in the article much more of a substantive proposal (see subsection 3) than Ballantyne would seem to be willing to acknowledge.

As I have already spelled out, besides the considered alternative interpretations, the standard reading of

Dewey's famous article is in terms of a clear-cut critique of behaviorist psychology before it had established in the American academic community. In my opinion, this remains however a poor interpretation of the ideas laid down by Dewey: From a contemporary perspective, a richer interpretation can be fully justified and 'come to life' given the dynamicist background I set here. Specifically, in opposition to the standard reading, I think critical as well as positive aspects can be distinguished in the article regarding the establishment of a certain approach to the study of cognitive phenomena. In what follows I will assume this distinction in order to analyze certain central themes proposed by Dewey and recovered by the dynamical approach in the cognitive sciences.

A final point worth stressing is that the particular interpretation I will propose is a markedly methodological reading of Dewey's critique and proposal, both interpreted as concerning the definition of variables by experimental psychologists, the explanatory style and the object of study in psychology. It can be mentioned that this kind of strategy is explicitly rejected by Jordan (1998). This author, for one part, understands that Dewey's critique must be interpreted on a theoretical, not methodological, level (not, for example, in terms of the manipulation and control of independent variables to study its relation with dependent variables) and, for another part, proposes that Dewey is making use of a specific methodological distinction (between stimulus and response) to theorize about perception. Although Jordan is not interested as I am in projecting relations of continuity with approaches which clearly exhibit a methodological dimension, it will be clear that the proposed interpretation does not misrepresent Dewey's reflections and that, much on the contrary, shades some light on the warnings of an acute critic and his call for a style of psychological research that only very recently has taken on its full form.

#### 4.2. Critical aspects

As anticipated, I start with certain critical aspects that can be extracted from Dewey's article, directed towards the format of psychological research. The various proposals framed within embodied cognitive science take as their starting place some kind of opposition to classical cognitive science, i.e., they developed mainly as a reaction to established models of cognitive research. In this regard, it is worth highlighting that Dewey's main motivation in the article is a discomfort with then active or growing tendencies and the corresponding search for alternatives to the models on offer in psychology (a search which then took shape in the soon to be baptized functional psychology). In the second paragraph, Dewey makes clear:

In criticising this conception [the reflex arc] it is not intended to make a plea for the principles of explanation and classification which the reflex arc idea has replaced; but, on the contrary, to urge that they are not sufficiently displaced, and that in the idea of the sensori-motor circuit, conceptions of the nature of sensation and of action derived from the nominally displaced psychology are still in control. (Dewey 1896: 357)

Besides favoring Ballantyne's critique of the reading 'reflex arc versus sensorimotor circuit', the presence of a reactive impulse behind the philosopher's subsequent elaborations can be appreciated very clearly.

Let's now attend to the core of Dewey's proposal: the critical assessment of the concept of reflex arc taken as a unifying principle in psychology. The critique encloses two central points that are picked up by several lines of work in the dynamical approach, especially in its departure from cognitivism. In the first place, the critique conceals in the already introduced artificiality of the stimulus / response constructs conceived as separate events, an assault on the persistent associationism in the cognitive sciences: this assault has its roots in the input-output scheme reproduced by behaviorists to design and conduct experiments but also to articulate subsequent experimentally informed theorizing. The idea of a

methodology of the imposed stimulus (Reed 1996: 269), which researchers adopted from XIX century neurophysiology, has sometimes been construed along these lines as an inappropriate methodological framework for psychological processes.

In cognitive psychology, for example, the input-output scheme may manifest itself in the practice of directly referring measurements taken from human behavior to causal properties of specialized components of the mind-brain. The case of reaction-time measurement, as popularized by Sternberg (1969), is a prototypical tool underlying this kind of practices, which consists in measuring the time elapsed between the presentation of a stimulus and the onset of the execution of a given task: By measuring the time subjects take to recognize certain relations between perceived objects, carry out logical puzzles, make choices, and so on, inferences are made about the components and mechanism of the underlying cognitive processes. This can be generally seen as an 'atomistic' tendency consisting in isolating elements within the process which goes from perception to motor response.

For another part, as we have seen, the dynamical approach is characteristic in its adoption of a global approximation towards the system under study, in which its inputs are modeled as perturbations of its internal dynamics. Likewise, the output of the system is not conceived as an inert product and in particular dissociable from the system's own dynamics. Recent modeling work on simple behavioral phenomena along these lines, such as the cases of categorical perception in Randall Beer's evolutionary robotics program (Beer 2003) and the task of retrieving a hidden object in Esther Thelen's developmental psychology program (Thelen et al. 2001) clearly answers to the kind of concerns anticipated by Dewey.

The second central point behind the critique of the reflex arc idea, also retrieved by the dynamical approach, is

even stronger from a philosophical point of view. As I have anticipated, Dewey speaks of a dualism – a kind of metaphysical dualism, as he specifies later on (Dewey 1896: 365) – which stems from the idea of the reflex arc and its application to psychology. This has been an oft invoked accusation by dynamicist philosophers and scientists. In spite of the resounding materialism hailed from virtually every area of cognitive science, the critical point here is that in current research practices a kind of dualism, almost certainly not of a metaphysical kind but which impacts at a methodological level, is still at work. A common framing of this accusation is that this kind of dualism underlying cognitivism is a byproduct of the enduring computational metaphor: according to this sort of dualism it would be assumed that the chomskian mind-brain (Chomsky 1989) operates under principles different from those underlying the rest of the body and the natural world.

It is worth mentioning that during the last few years the strength of radical functionalism and the multiple realizability thesis – firm philosophical mainstays of the first cognitivist wave which in different ways authorized the cognitive scientist to leave aside the physical substrate where cognitive processes instantiate – has considerably weakened, partly on account of the recent emergence of cognitive neuroscience. Still, the accusation of a filtered dualism in cognitive-scientific research has undoubtedly been a search engine in the dynamical approach from the first years of the '90s, when it was taking off. But, more importantly, the application of dynamical systems theory inasmuch as it provides a vocabulary with the potential to reconcile different levels of description and explanation (for example, cognitive, behavioral and brain processes) constitutes a promise to sort out the eventual isolation between different levels of theorization in the cognitive sciences.

At a highly general theoretical level, the main idea is that physical interaction with the world is as such part of the

cognitive activity (this, in rigor, is an idea that Dewey develops in detail later on in his *Essays in Experimental Logic*). As much as that what results is still more properly a project still in its infancy, it can be claimed that the dynamical approach sets itself up on a reaction to a kind of dualism, in the end between body and mind, already identified by Dewey in the psychology of his time.

An additional critical aspect of the Deweyan proposal, also picked up by the dynamical approach, hinges on the problem of the object of study of a scientific psychology. As a foundational text of functional psychology, "The reflex arc concept in psychology" reaffirms the idea that cognition manifests generally before the cognitive agent's immediate difficulties and needs: In particular, the idea of adaptation plays a central role in the Deweyan conception of cognition, mainly due to the strong Darwinian influence on the philosopher (Dewey 1910). The associated requirement of ecological validity is one of the main characteristic features not only of the dynamical approach but also more generally of embodied cognitive science, which in turn displays the great intellectual debt towards the gibsonian ecological approach.

Now, the critical side to this – not made explicit by Dewey and strictly a little discordant with later developments such as *Experience and Nature* (on the role of the environment in Dewey, see for example Godfrey-Smith 1996a: 115) – is an objection to the framing of psychological questions in terms of the adjustment of a cognitive system to the demands posed by stimuli and its subsequent generation of an adequate motor response: this kind of framing, in fact, recapitulates the characteristic dynamic of the cognitivist model 'perceptual input-cognitive processes-motor output', typically rehearsed in the context of such activities as planning and problem-solving. Clearly, this last point also stems out from the assumption of a clear-cut division between stimulus and response, heart of Dewey's critical stand.

Finally, and taking up again the first critical point behind the reflex arc idea relative to the stimulus-response scheme, this same scheme has an impact on the kind of explanation aimed at in the cognitive sciences. Several philosophers of cognitive science tried to characterize the cognitivist style of explanation. However, many of the most influential versions (for example, Clark 1997, Bechtel 1998, Haugeland 1978) share the feature under the Deweyan assault. This kind of explanation centrally assumes a strategy of decomposition of the relevant parts of the system in terms of their relative contribution to the information processing necessary to perform a given task. This analytical assumption is a central corollary of the reflex arc critique aimed as it is at unveiling the associationist residues in psychological research: It surfaces as much at the level of research setting as it also does in the style of explanation assumed in the cognitive sciences.

I add two related final remarks. In the text Dewey explicitly refers both to a derived simplification that does not make justice to the object under study and to an undesired staticity in psychological explanation; both features can be associated to the fragmentation and the linear treatment of individual components, typical of cognitivist explanation – a procedure that some moderate critics label ‘boxology’ (Dennett 2001). I quote below two fragments which, respectively, illustrate both points. In the first place, regarding the danger of oversimplification in psychological explanation, and specifically referring to his invitation to think more in terms of what he calls an organic circuit than in terms of the reflex arc, Dewey states: “It is not a question of making the account of the process more complicated, though it is always wise to beware of that false simplicity which is reached by leaving out of account a large part of the problem” (Dewey 1896: 363-364).

Secondly, Dewey later on spells out the known psychological or historical fallacy, in this case directed towards the illegitimacy of abstractions couched upon

the reflex arc concept. We’ll see later on how the dynamical approach can be interpreted mainly as an attempt to avoid this kind of fallacy. Dewey portrays it as follows:

A set of considerations which hold good only because of a completed process, is read into the content of the process which conditions this completed result. A state of things characterizing an outcome is regarded as a true description of the events which led up to this outcome. (Dewey 1896: 367)

When this is understood in the context of a debate on psychological explanation (once again, as philosophers of the special sciences) the core of the critique hinges on its staticity: a focus on the study of psychological or mental states (“state of things”) taken as valid for the study of the (dynamical) processes which lead to them.

#### **4.3 Positive aspects**

Let’s turn now to consider some of the positive aspects that can be extracted from Dewey’s article towards the establishment of a specific approach in psychology. To begin with it is convenient to round up the issue of psychological explanation. In his appeal to a more encompassing organizing principle that won’t reduce to rigid distinctions as those of sense, idea (in today’s terminology, cognition) and action, Dewey proposes the idea of coordination: he considers that stimulus, idea and response are phases of a division of labor embedded in a global coordination of action directed towards adaptive ends. This notion of coordination can be defined as a continuous and coordinated sequence of events for the maintenance of a particular state of organization in the agent relative to environmental changes.

In relation to this, it’s worth mentioning that one of the pioneering and most fertile lines of work clearly falling within the dynamical approach in the cognitive sciences is the coordination dynamics program lead by J. A. Scott Kelso (1995). This program constitutes an attempt to



identify, through the tools of dynamical systems theory, the key coordinative variables of a particular system under scrutiny, and to describe its dynamics, conceived as rules which determine the stability and change of coordinative patterns, and the non-linear coupling between the components generating those patterns. I specifically mention Kelso not only for his historical relevance in the recent establishment of the dynamical approach but also because his program is an example of how the idea of coordination in a psychological context has been recovered and put to work in the experimental and modeling practices in the cognitive sciences.

Now, what I want to stress here, with reference to psychological explanation, is specifically the interactive character brought to the fore once the idea of coordination is placed at the basis of psychological and cognitive-scientific inquiry. The already introduced idea of coupling (between agent and environment, and brain and body) in fact promotes a sort of interaction-centered approximation, consisting in the study of cooperative behavior between many interacting elements, at the same time that the language of dynamical systems theory represents the main instrument to enable an approximation of this kind.

A related point is that in this way the unified treatment of interactions between perception and action, conceived as overlapping and cognitive processes, is encouraged – in stark contrast with the already mentioned assumption of the segmentation of cognitive processes, commonplace in cognitive psychology. By and large, moreover, attention is shifted from mental states and their contents towards adaptive processes in its temporal development, in full agreement with Dewey's warning about the psychological fallacy.

In the article there are several theoretical projections that later on have been endorsed as mainstays of the psychological account of perception (especially, of vision) put forward by James J. Gibson, without a doubt

one of the main scientific antecedents of the dynamical approach. For instance, regarding the general preconception of the nature of perception and its function, Gibson's view and the view Dewey develops in "The reflex arc concept in psychology" is almost equivalent. In reference to the Jamesian example of the boy and the candle, through which he illustrates his notion of coordination, Dewey affirms: "...we now have an enlarged and transformed coordination; the act is seeing no less than before, but it is now seeing-for-reaching-purposes" (Dewey 1986: 359). This idea of "seeing-for" is absolutely consonant with the gibsonian stand on the role of vision: Gibson (1979) draws a clear-cut distinction between understanding the purpose of vision as, on the one hand, one of reconstructing from the bottom up a model of the world from primitive stimuli (that is, in the fashion of classical representationalist proposals such as Marr's (1985)) and, on the other hand, one of guiding the actions of the perceiver in a dynamical environment. In line with this second perspective, the immediate methodological upshot for the study of perception is the idea that the active role of the agent in its environment should not be relegated, an idea that has been put down to work by Gibson himself in his experimental settings.

This theoretical line that sketches the intimate relation between perception and action has been vigorously reassessed by Alva Noë (2004; for a cognitive science oriented presentation, see O'Regan & Noë 2001) among other theorists. Here too affinities on a theoretical level are striking. The main Deweyan idea reintroduced in this case is that perception is part of a coordinative sensorimotor process. In Leahey's words, "In developing his own motor theory of mind, Dewey does not take perception to be the passive register of an impression but a behavior in itself, conditioned by other behaviors happening at the same time" (Leahey 1998: 347).

Noë states as his main thesis precisely the idea that perception is a kind of behavior. In a more precise

formulation, Noë's position establishes that the ability to perceive is partially constituted by what he terms 'sensorimotor knowledge', i.e., the practical, implicit grasp of sensorimotor contingencies, which in turn constitutes the way sensory stimulation varies as the perceiver and the perceived object move. With this in mind consider now the following declaration by Dewey, again in the context of the boy and the candle example:

Now if this act, the seeing, stimulates another act, the reaching, it is because both of these acts fall within a larger coordination; because seeing and grasping have been so often bound together to reinforce each other, to help each other out, that each may be considered practically a subordinate member of a bigger coordination. (Dewey 1896: 359)

It does not seem excessive to assert that the roots of the current proposal in terms of the formation of sensorimotor contingencies as a kind of practical and implicit knowledge are to be found in this proposal of a reinforcement generated by the reiterated joint activity of seeing (or perceiving) and acting.

Another positive aspect of Dewey's view, once again inherited by dynamical approach, concerns the problem of defining the object of study in psychological (and cognitive-scientific) research. As I have already mentioned, the most purely functionalist (in the sense of the classical functional psychology) thesis that can be extracted from the article is that behaviour and cognition can be understood not in terms of its constituting parts but in terms of the role they play in the cognitive system's adaptation to its environment. From a methodological point of view, this thesis fundamentally entails a larger unit of analysis, more encompassing than the chomskian mind-brain, exclusive object of study in the cognitivist tradition.

In particular, the importance conferred to the pragmatic context (in which something takes the form of stimulus in relation to another event configured as a response) implies, at the level of research setting, the inclusive

consideration of the agent's actions, their effects on perceptive processes, behavioural subroutines and relevant features of the environment. The importance of taking into account the role of an embodied agent acting in a changing environment for the study of cognitive processes thus affects our take on the object of psychological and cognitive-scientific study.

A last central point I want to highlight is the relevance of temporal considerations for the study of cognition. This is a key aspect of the dynamical approach, especially with regards to the application of dynamical systems theory and by extension its ability to describe the temporal evolution of complex systems' behaviour. Although in the article Dewey is not explicit on this matter, his rejection to understand stimulus, idea and response as separately occurring events goes in this direction. (It is also worth adding that, in his *Essays in Experimental Logic* – originally written in 1903 and hence close to "The reflex arc concept in psychology" in the author's intellectual evolution – Dewey stresses the importance of temporal considerations in psychological research and, in this way, can be considered a prominent philosopher who connected a focus on the temporal dimension of thought processes with a pragmatist view of knowledge.)

## 5. Conclusion

Building, on the one hand, on general considerations surrounding Dewey's pragmatism and, on the other hand, on considerations elaborated from an analysis of both critical and positive contributions in "The reflex arc concept in psychology", I have justified a strong continuity between the philosopher's elaborations and recent embodied cognitive science, specifically the dynamical approach. The critique of the reflex arc concept and the related proposal hinging on the idea of coordination, both developed in the 1896 article, can thus be regarded as relevant historical contributions for

a study of the intellectual roots of these recent tendencies in contemporary cognitive science.

The hypothesized affinity at a theoretical and methodological level of psychological and, in general, cognitive-scientific research setting is sustained on a series of common themes already present in Dewey's article and elaborated there as conceptual projections; these themes are recovered and refined by current approaches, functioning today as a sort of operational framework put down to work in research contexts. I have thus highlighted Dewey's role as an intellectual precursor in their development, a precursor of broad scope, considering the number of these common themes, and of great depth, considering their high degree of compatibility. Additionally, this historical connection in turn reveals how the critique of the stimulus-response or input-output scheme enshrines much of the theoretical assumptions and methodological profile distinctive of the dynamical approach in the cognitive sciences.

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